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Fecal microbiota transplantation in a post-bariatric patient with sibo: a clinical experience report

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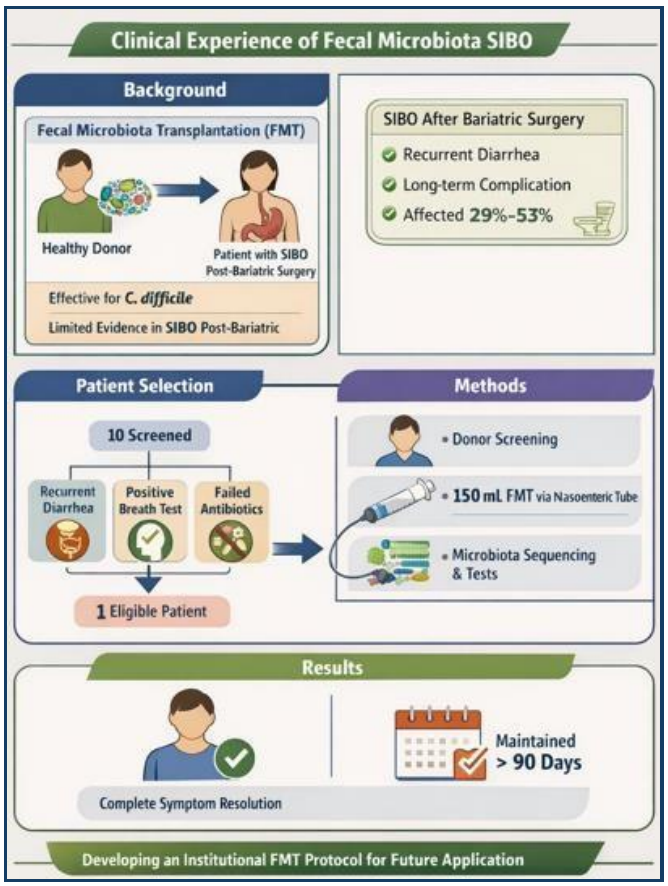
Abstract

Background: Fecal Microbiota Transplantation (FMT) is a therapeutic intervention involving the transfer of gut microbiota from healthy donors to individuals with dysbiosis, with the aim of restoring microbial homeostasis. Its efficacy is well established for the treatment of recurrent *Clostridioides difficile* infection. However, evidence supporting its use in small intestinal bacterial overgrowth (SIBO), particularly in patients who have undergone bariatric surgery, remains limited. Studies report that the prevalence of bacterial overgrowth after Roux-en-Y gastric bypass ranges from 29% to 53%, depending on the duration of postoperative follow-up. This study reports a clinical experience addressing this gap. **Objectives:** It was to report the clinical experience of FMT in a post– Roux-en-Y gastric bypass patient with SIBO and to develop an institutional FMT protocol for future clinical application. **Methods:** This prospective, open-label clinical experience was approved by the Research Ethics Committee of a tertiary care hospital, Fundação Hospital Adriano Jorge (FHAJ), under number 2.475.214, Manaus, Brazil. Ten post-bariatric patients under outpatient follow-up were screened. All presented recurrent diarrhea for at least three months despite a minimum of three prior antibiotic treatments. Inclusion criteria included a positive breath test for SIBO, altered functional stool analysis, or confirmed *Clostridioides difficile* infection by fecal toxin assay. Potential donors, preferably first-degree relatives, underwent clinical assessment and laboratory screening. Clinical and laboratory data were collected from both donor and recipient, including 16S rRNA fecal microbiota sequencing (Bioma4me™), bioelectrical impedance analysis, and habitual dietary intake assessment. Recipient evaluations were performed at baseline (T0) and 90 days after FMT (T1). The primary outcome was sustained resolution of diarrhea for at least 90 days following the procedure. **Results:** Of the ten patients screened, one met all inclusion criteria and underwent FMT. The procedure consisted of a single administration of 150 mL of fecal suspension diluted in 0.9% saline, delivered enterally via a nasoenteric tube positioned endoscopically in the distal alimentary limb. The treated patient achieved complete remission of gastrointestinal symptoms, maintained for more than 90 days. **Conclusions:** This clinical experience supported the development of an institutional FMT protocol and suggests potential benefit of FMT in selected post-bariatric patients with refractory SIBO. Nevertheless, larger studies with longer follow-up are required to

establish the safety, efficacy, and reproducibility of FMT in this specific clinical setting. This study was funded by the Amazonas Research Foundation (FAPEAM).

Keywords: Fecal Microbiota Transplantation. Small Intestinal Bacterial Overgrowth. SIBO. Bariatric Surgery.

Graphical abstract



Source: Own authorship.

Introduction

Fecal Microbiota Transplantation (FMT) is a therapeutic intervention aimed at restoring intestinal microbiota balance through the introduction of beneficial microorganisms from a healthy donor into the gastrointestinal tract of a recipient. Traditionally, FMT has been successfully used in the treatment of recurrent *Clostridioides difficile* infections, demonstrating significant efficacy in symptom resolution and prevention of recurrence **[1]**.

More recently, attention has turned to the application of FMT in other conditions associated with intestinal dysbiosis, such as small intestinal bacterial overgrowth (SIBO). In this context, SIBO can be defined as the presence of an abnormally high number of pathogenic coliform bacteria in the small intestine[2]. It is associated with a wide range of intestinal motility disorders and with surgical procedures that result in intestinal stasis **[2]**. The most common symptoms include diarrhea, abdominal pain, and flatulence. Currently, the optimal approach to treating SIBO involves management of the underlying condition, eradication of excessive bacterial overgrowth, and correction of associated nutritional deficiencies **[2]**.

During treatment, antibiotics, probiotics, and synbiotics are commonly used with the aim of modulating the intestinal microbiota and controlling symptoms[3]. In cases of recurrence, repeated courses of antibiotics may be required to reduce pathogenic intestinal microbiota and maintain symptom control, as relapses are frequent and additional treatments often become unavoidable. Clinically, SIBO may lead to symptoms such as abdominal distension, diarrhea, nutrient malabsorption, and gastrointestinal discomfort **[3,4]**.

In this context, obesity is considered one of the major epidemics of this century and is associated with multiple comorbidities, adversely affecting quality of life and longevity **[5]**. Bariatric surgery (BS) is an effective approach for sustained weight loss in patients with severe obesity and involves surgical procedures that alter the gastrointestinal tract, reducing caloric intake capacity and nutrient absorption. Patients undergoing BS are at increased risk of postoperative nutritional deficiencies, attributable to factors such as preoperative deficiencies, reduced dietary intake, inadequate supplementation, nutrient malabsorption, and lack of appropriate nutritional and medical follow-up **[5,6]**.

Patients undergoing bariatric surgery, particularly those who have undergone procedures such as Roux-en-Y Gastric Bypass (RYGB) and sleeve gastrectomy, experience anatomical and functional changes in the gastrointestinal tract that may predispose them to the development of SIBO. Studies indicate that the prevalence of bacterial overgrowth after RYGB ranges from 29% to 53%, depending on the duration of postoperative follow-up. Furthermore, the presence of SIBO in these patients is associated with persistent gastrointestinal symptoms and reduced quality of life **[7-9]**.

In this context, FMT may be hypothesized as a potential therapeutic approach for this type of complication in post-bariatric patients. Although studies evaluating the efficacy of FMT in this specific setting remain limited, the intervention appears promising in restoring intestinal microbiota and improving associated symptoms, thereby optimizing clinical outcomes and quality of life.

The objectives of this study were to evaluate the use of FMT in post-bariatric patients with SIBO refractory to conventional antibiotic therapy, by

comparing clinical and laboratory data before and after the procedure, with the aim of developing an institutional clinical protocol. This protocol was designed based on information obtained from the technical teams of other FMT centers and international consensus statements and guidelines **[10-12]**.

Methods

Study Design and Ethical Approval

This was a prospective, open-label clinical study conducted at a tertiary care hospital, Fundação Hospital Adriano Jorge (FHAJ), and approved by the Research Ethics Committee under number 2.475.214. Eligible recipients were patients followed at the institution's outpatient nutrition clinic after bariatric surgery. The informed consent was applicable.

Eligibility

Inclusion criteria comprised post–Roux-en-Y gastric bypass patients aged ≥18 years with a clinical history compatible with persistent intestinal dysbiosis, defined as recurrent diarrhea for at least three nonconsecutive months, flatulence, and abdominal pain, despite at least three prior antibiotic treatment courses administered on different occasions. Additional inclusion criteria included a positive hydrogen breath test for SIBO, associated with altered functional stool analysis or *Clostridioides difficile* infection confirmed by detection of monoclonal antibodies to toxins A and B.

Exclusion criteria included patients who responded to standard treatment, pregnant women, Indigenous patients, individuals with severe immunosuppression, and patients with active inflammatory bowel disease or ongoing gastrointestinal malignancies.

Participants and Procedures

For donor selection, relatives of the recipient individuals were evaluated, provided they met the following criteria: body mass index < 30 kg/m²; no use of illicit drugs; nonpregnant women; absence of infectious diseases previously screened for and during the execution of this protocol (HIV, viral hepatitis, and syphilis); and no history, within the previous three months, of travel, blood transfusion, tattooing or piercing, change of sexual partner, or incarceration. For recipients with positive *Clostridioides difficile* markers, family donors residing in the same household were excluded.

Donors were healthy volunteers who underwent clinical and laboratory screening to exclude infectious and gastrointestinal diseases. Donors were required to have daily bowel movements and were evaluated to rule out the presence of *C. difficile*, other pathogenic intestinal bacteria, parasites, as well as other transmissible diseases, metabolic disorders, and autoimmune diseases, in accordance with the local institutional protocol see Supplementary Material), developed based on information obtained from technical teams at other FMT centers and on international consensus statements and clinical guidelines **[10-12]**.

After donor selection, clinical and laboratory data were collected from both recipients and donors, including intestinal microbiota sequencing by 16S Rrna (Bioma4me™), bioelectrical impedance analysis, and habitual dietary intake assessment. Recipient reassessments were conducted at T0 (baseline, before FMT) and T1 (90 days after FMT).

SIBO diagnosis was established using a hydrogen breath test following oral glucose or lactulose challenge. In selected cases, functional stool analysis was also performed to evaluate stool characteristics. Fecal microbiota sequencing was performed on stool samples collected from both donors and recipients using 16S rRNA gene sequencing (Bioma4me™) by a certified external laboratory. Sequencing data were processed and analyzed using the laboratory's standardized bioinformatic pipeline, enabling qualitative and quantitative assessment of the intestinal microbiota with taxonomic classification at the phylum, genus, and species levels.

FMT was performed via the upper enteroscopic route, in accordance with established biosafety requirements and standardized clinical protocols, after written informed consent was obtained. Fecal material infusion was carried out under fasting conditions, following prior bowel preparation as described in the local protocol. Administration was performed via a nasoenteric tube positioned by upper gastrointestinal endoscopy into the alimentary limb, as distally as possible, and delivered as a single dose. After completion of the infusion, the patient was monitored until discharge, with subsequent clinical and nutritional follow-up as previously described.

Preparation of the selected donor included prophylactic treatment for intestinal parasites up to seven days prior to FMT. On the morning of the procedure, stool samples were collected in a clean, dry, airtight plastic container and delivered to the laboratory for preparation of the fecal suspension. If same-day collection was not feasible, stool samples could be collected the day before the procedure, provided they were refrigerated until delivery and not frozen. Donor stool was mixed with sterile saline, homogenized, and administered immediately.

Sample preparation was conducted within the clinical laboratory, using approximately 50 g of stool diluted in 150 mL of 0.9% saline solution, followed by filtration to reduce solid particles and minimize the risk of nasoenteric tube obstruction, as illustrated in Figure 1.

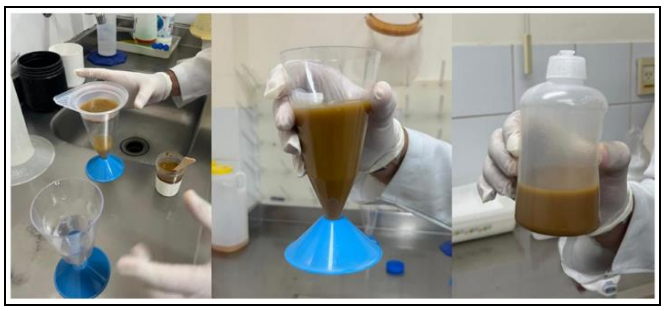


Figure 1. Donor fecal material collected for Fecal Microbiota Transplantation (FMT) and processing for administration. Source: Own authorship.

Regarding outcome assessment, patients were followed by a multidisciplinary team and reassessed for the following parameters:

- Fecal microbiota composition (before and after FMT);
- Clinical symptoms (diarrhea, flatulence, and abdominal pain);
- Nutritional status (anthropometric and laboratory variables for assessment of macro- and micronutrients);
- Body composition assessed by bioelectrical impedance analysis.

The primary outcome was the absence of diarrhea for 90 days or longer, along with reduction of signs and symptoms related to SIBO. Given the exploratory nature of this clinical experience and the inclusion of a single recipient–donor pair, data were analyzed descriptively. Clinical, nutritional, and microbiota-related variables were compared within the same individual before (T0) and after FMT (T1). No inferential statistical tests were performed, due to the single-patient design, analyses were limited to descriptive comparisons, focusing on within-subject changes over time.

Results

Of the 10 patients initially screened, only one was included in the study (four died due to COVID-19, one did not have a confirmed diagnosis of SIBO, and four lacked compatible donors). After screening, a single compatible donor was identified during the post-pandemic safe window, when sanitary conditions allowed for the collection and handling of biological material.

Tables 1 and 2 present the general characteristics, medical history, and laboratory data of the FMT donor and recipient, including clinical, nutritional, and microbiological parameters prior to transplantation, as well as microbiota sequencing data of the recipient and donor at the time points evaluated in relation to FMT.

Table 1. Baseline characteristics, medical history, and laboratory data of the FMT donor and recipient, including clinical, nutritional, and microbiological parameters prior to transplantation.

Variable/ Description	Donor	Recipient
City of origin	Manaus	Manaus
Summary of medical history	Not applicable	Surgical history: Roux-en-Y gastric bypass (RYGB) 7 years ago: • Preoperative weight: 99.6 kg • Postoperative weight loss:~50kg • Favorable immediate postoperative course Recent clinical course (last 10 months): • Severe asthenia • Lower limb edema • Amenorrhea • Steatorrhea with undigested food remnants • Denies blood or mucus in stools Hospitalizations: • Required for investigation of malabsorption syndrome • Two ICU admissions (most recent due to sepsis) • Parenteral nutrition administered • Lowest recorded weight: 44.9 kg Treatments received: • Three courses of antibiotics targeting intestinal causes • Pancreatic enzyme therapy initiated Current status: • Improvement in steatorrhea, edema, and amenorrhea • Persistent recurrent flatulence and foul-smelling stools • Intermittent episodes of diarrhea • Dietary plan adjusted accordingly
Comorbidities	None reported	Hypothyroidism, exocrine pancreatic insufficiency, malabsorption syndrome, late postoperative period after Roux-en-Y bariatric surgery
Medications / Supplements	None reported	• Folic acid 5 mg, 1 tablet daily • Multivitamin and multimineral, 2 tablets daily • Chelated zinc 40 mg, 1 tablet daily for 60 days • Vitamin D3 5,000 IU, once daily • Vitamins (thiamine 100 mg, pyridoxine 100 mg, cyanocobalamin 1,000 IU) IM, 3 times/week, total 9 doses • Levothyroxine 50 mcg, 1 tablet on an empty stomach

		• Pancreatic enzymes (Creon) 25,000 IU, 2 capsules before main meals and 1 capsule before intermediate meals • Creatine 5 g, once daily • Whey protein 25 g/day • Recent administration of intravenous ferric hydroxide saccharate
Lactulose Breath Test for Small Intestinal Bacterial Overgrowth (SIBO)	Not applicable	Positive
Functional stool analysis (stool characteristics)	• Consistency: pasty • Shape: cylindrical • Odor: fecal • Viscosity: absent • pH: 7.0 • Fat content: <5% • Occult blood: absent	• Consistency: pasty • Shape: cylindrical • Odor: fecal • Viscosity: absent • pH: 6 • Fat content: <5% • Occult blood: absent
Parasitological stool test	Negative	Negative
Clostridioides difficile fecal toxin (index)	0.001% (clinically insignificant amount)	0.69 (non-reactive)
HIV serology	negative	negative
Hep A (IgM)	negative	negative
Hep B (HBsAg/anti-HBs)	0.25 ml 1346 mUI/mL (reagente)	Negative 40.27 mUI/mL
Hep B (HBsAg/anti-HBs)	non-reactive	4.39 18.89
Hep C (Anti-HCV)	non-reactive	non-reactive
Syphilis serology	Negative	Negative
Infectious diseases in the past 3 months	No history of	Not applicable
Travel in the past 3 months	No history of	Not applicable
Blood transfusion in the past 3 months	No history of	Not applicable
Received tattoo or piercing in the past 3 months	No history of	Not applicable
Change of sexual partner in the past 3 months	No history of	Not applicable
Illicit drug use in the past 3 months	No history of	Not applicable
History of incarceration in the past 3 months	No history of	Not applicable
Antibiotic use in the past 3 months	No history of	Not applicable
Comorbidities - chronic diarrhea or constipation; history of inflammatory bowel disease (IBD), irritable bowel syndrome (IBS), or colorectal cancer (CRC); atopy; severe obesity; immunosuppression	No history of	Not applicable

Source: Own authorship.

The primary outcome, remaining free of diarrhea for 90 days, was achieved. Dietary characteristics of the recipient remained largely unchanged, with a mean energy intake of approximately 1,650 kcal at T0 and 1,750 kcal at T1. A reduction in body weight was observed at follow-up (baseline weight: 55 kg; weight at 90 days: 52.4 kg), accompanied by a slight decrease in body fat percentage and an increase in skeletal muscle mass. No adverse events were reported following FMT, and the patient remained clinically stable throughout the post-procedure follow-up.

Table 2. General characteristics and fecal microbiota sequencing findings of the donor and recipient at baseline (T0) and 90 days after fecal microbiota transplantation (FMT).

General characteristics	Donor – baseline (T0)	Recipient – baseline (T0)	Recipient – T1 (follow-up)
Age (years)	45	44	44
Weight (Kg)	80	55	52.4
Height (m)	1.67	1.57	1.57
BMI (Kg/m2)	28.6	22.3	21.2
SMM (kg)	30.0	19.0	21.5
% BF	30.0	30.0	28.0
Overall mean energy intake (kcal/day)	2850	1650	1750
Overall mean protein intake (g/day)	110	60	70
Fecal microbiota sequencing			
Phylum			
Indicator abundance F + B (between 85% to 95%)	94.74	83.89	46.43
Proportion - indicator F/B (between 0.7 to 1.0)	0.67	4.39	18.89
Genus			
Diversity (greater than 7)	3.76	7.53	6.44
Distribution	Inadequate	Inadequate	Inadequate
Species			
Richness (greater than 400)	720	1027	585
Protective bacteria			
***Akkermansia muciniphila* (between 1% to 5%)**	0.014	0.035	0.049
***Faecalibacterium prausnitzii* (between 5% to 15%)**	12.907	2.417	1.033
***Eubacterium rectale* (between 1% to 13%)**		0.059	
***Bifidobacterium spp* (between 1% to 6%)**	1.782	0.763	1.731
Pathogenic bacteria			
***Bacterioides fragilis* (<0,5%)**	0,053	0,013	0,115
***Clostridium difficile* (not especified)**	0	0,003	
***Serratia marcescens* (not especified)**	0	0,002	0,005
Atypical findings			
***Ruminococcus gnavus* (<0,1%)**	0,034	0,016	0
***Bilophila wadsworthia* (desirable <0,1%)**	44,37	14,6	0,549
Dialister succinaliphilus			16,45
Candida albicans	1,61	0,64	0

BMI= body mass index; SMM = skeletal muscle mass; %BF = body fat percentage; F/B = Firmicutes/Bacterioidetes. Reference values, cut-off points, and classifications (e.g., desirable, not specified, indicator abundance) were provided by the laboratory performing the fecal microbiota sequencing and are based on proprietary bioinformatic analysis pipelines. Source: Own authorship.

Figures 2 to 4 respectively show the relative abundance and distribution of bacterial taxa in the FMT donor's fecal microbiota, the fecal microbiota composition of the FMT recipient at baseline (T0), and the fecal microbiota composition of the FMT recipient at 90 days after transplantation (T1).

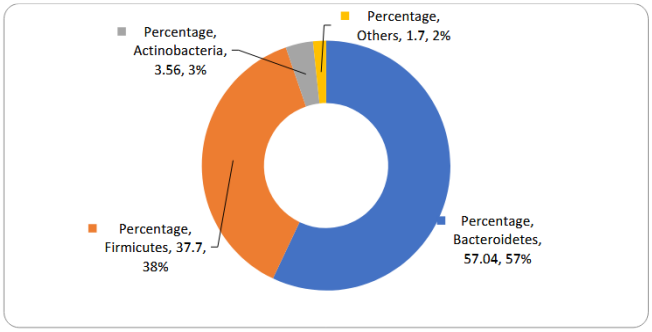


Figure 2. Relative abundance and distribution of bacterial taxa in the FMT donor's fecal microbiota. Source: Own authorship.

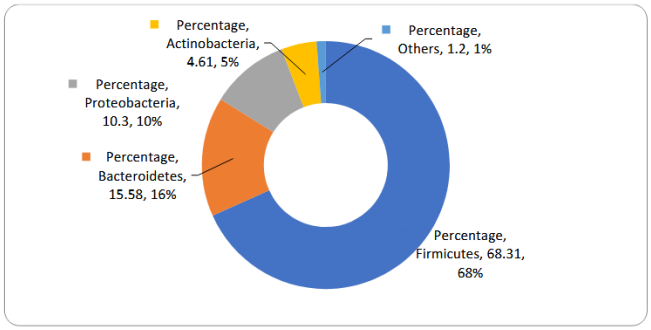


Figure 3. Fecal microbiota composition of the FMT recipient at baseline (T0). Source: Own authorship.

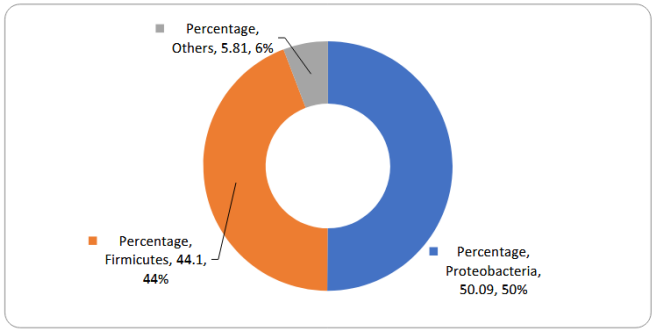


Figure 4. Fecal microbiota composition of the FMT recipient at 90 days after transplantation (T1). Source: Own authorship.

Discussion

Fecal Microbiota Transplantation (FMT) has become established as an effective therapeutic strategy for restoring intestinal ecosystem balance in patients with dysbiosis-related disorders, particularly recurrent diarrhea, and is well consolidated for the treatment of refractory pseudomembranous colitis **[13,14]**. In contrast, small intestinal bacterial overgrowth (SIBO) represents a frequent complication associated with diarrhea resulting from the excluded limb in patients undergoing Roux-en-Y gastric bypass surgery[7]. This unfavorable condition arises from an imbalance between colonic flora and pathogenic bacteria and, if left untreated, may progress to malnutrition, anemia, and malabsorption syndrome **[7]**.

In this context, analysis of the intestinal microbiota has driven research toward considering it a microbial human organ, with important roles in immunity and energy metabolism, raising the possibility that many diseases may result, at least in part, from microbiota-related dysfunction **[2]**. Based on this premise, the investigation and treatment of bacterial overgrowth in post-bariatric patients through the use of FMT becomes a plausible therapeutic approach. Accordingly, this study focused on post-bariatric patients with SIBO who were refractory to conventional antibiotic therapy.

In the present study, the recipient exhibited, at baseline (T0), an intestinal microbiota profile characterized by low bacterial diversity, reduced predominance of Firmicutes and Bacteroidetes, and altered microbial composition, consistent with dysbiosis commonly observed in patients with SIBO. These findings are characteristic of dysbiosis states. In addition, the recipient presented a positive hydrogen breath test for SIBO at baseline.

Following FMT, at 90 days of follow-up (T1), clinical improvement was observed, with complete resolution of diarrheal episodes throughout the follow-up period. However, post-intervention analysis of the intestinal microbiota revealed an increased relative abundance of Proteobacteria in the recipient at T1. This finding warrants attention, as expansion of this bacterial phylum has traditionally been associated with inflammatory environments and microbial instability **[15]**.

Nevertheless, interpretation of microbiota diversity, richness, and indicator abundance was based on reference values provided by the sequencing laboratory, derived from bioinformatic analyses. Differences in analytical pipelines and reference databases across laboratories should be considered when comparing results with other studies. Although FMT has been extensively studied across multiple clinical conditions, its application in patients undergoing bariatric surgery remains an area of ongoing investigation. A randomized clinical trial conducted in Finland evaluated the impact of FMT administered six months prior to bariatric surgery on weight loss outcomes. The results demonstrated no significant differences in weight loss between patients receiving FMT from lean donors and those receiving placebo, both in the preoperative and postoperative periods. Both groups experienced comparable weight reductions following surgery, suggesting that FMT did not potentiate the weight loss effects of bariatric surgery **[16]**.

Despite these findings, evidence from animal models suggests that FMT may exert beneficial metabolic effects. In a study involving germ-free mice colonized with fecal microbiota from patients before and after bariatric surgery, animals receiving postsurgery microbiota exhibited improvements in insulin sensitivity and metabolic profiles compared with those colonized with pre-surgery microbiota **[17]**. These results indicate that FMT may have metabolic implications that warrant further investigation.

Although the donor met all predefined clinical and laboratory eligibility criteria and was considered suitable for fecal microbiota transplantation, the post-hoc bioinformatic analysis of the donor's fecal microbiota revealed variations in certain taxa relative to reference ranges provided in the sequencing report. These findings should be interpreted with caution, as current reference values for microbiota composition are not universally standardized and may vary according to methodological and populationspecific factors. Importantly, the recipient achieved a favorable clinical outcome, with complete resolution of diarrheal symptoms for at least 90 days following FMT and no reported adverse events.

The observed increase in Proteobacteria abundance in the recipient at follow-up may reflect a dynamic process of microbial reorganization and adaptation of the intestinal ecosystem in the post-bariatric context, rather than indicating an unsuccessful transplantation. This finding is consistent with previous experiences using FMT in patients with SIBO.

In a study by Mazzawi et al. (2018) **[18]**, patients with refractory SIBO treated with FMT showed significant improvement in gastrointestinal symptoms, even in the absence of complete normalization of hydrogen and methane breath tests, indicating a clinical benefit despite partial persistence of dysbiosis. Similarly, in a pilot study by Tariq et al. (2017) **[19]**, although FMT reduced abnormal microbial load in the small intestine in some SIBO patients, heterogeneity in the final microbiota composition and persistence of certain dysbiotic bacteria were observed, without preventing a positive clinical response.

A case report by Araújo et al. (2020) **[20]** further supports the feasibility of FMT administered via gastric tube in patients with dysbiosis, demonstrating clinical improvement even when complete microbiota normalization is not achieved. These results suggest that the therapeutic success of FMT in intestinal dysbiosis may result more from functional and immunological modulation of the microbiota than from the simple restoration of its original composition, even without complete normalization of its taxonomic profile **[19]**. Comparisons with previous SIBO experiences in other dysbiosis contexts reinforce that FMT efficacy may derive primarily from its metabolic and immunological effects rather than from exact replication of the donor microbiota.

Limitations

Currently, there is a lack of systematic studies specifically evaluating the use of FMT for the treatment of small intestinal bacterial overgrowth in patients undergoing bariatric surgery, particularly with detailed information on microbial sequencing of donors and recipients. Therefore, although the present experience was conducted on a limited scale, this did not compromise the achievement of one of the study's primary objectives: the development and testing of a clinically applicable model for future expansion and multicenter studies.

Conclusion

Based on this clinical experience, this report provides a descriptive account of the use of fecal microbiota transplantation in a post-bariatric patient with dysbiosis and small intestinal bacterial overgrowth. The findings should be interpreted as exploratory and hypothesis-generating, reinforcing the need for future prospective studies with larger sample sizes and long-term follow-up to better elucidate the role of FMT in specific patient populations.

CRediT

Author contributions: **Conceptualization-** Isolda Prado de Negreiros Nogueira Maduro, Aline de Vasconcellos Costa e Sá Storino, Henri Horstmann, Francielen Furieri Rigo, Sandro Adriano de Souza Lima Junior, Clara Valentina Noli Mendonza, Guilherme Teixeira de Araujo. **Data curation-** Isolda Prado de Negreiros Nogueira Maduro, Aline de Vasconcellos Costa e Sá Storino, Henri Horstmann, Francielen Furieri Rigo, Sandro Adriano de Souza Lima Junior, Clara Valentina Noli Mendonza, Guilherme Teixeira de Araujo; **Formal Analysis-** Isolda Prado de Negreiros Nogueira Maduro, Aline de Vasconcellos Costa e Sá Storino; **Investigation-** Isolda Prado de Negreiros Nogueira Maduro, Aline de Vasconcellos Costa e Sá Storino, Henri Horstmann, Francielen Furieri Rigo, Sandro Adriano de Souza Lima Junior, Clara Valentina Noli Mendonza, Guilherme Teixeira de Araujo; **Methodology-**Henri Horstmann, Francielen Furieri Rigo, Sandro Adriano de Souza Lima Junior, Clara Valentina Noli Mendonza, Guilherme Teixeira de Araujo; **Project administration-** Isolda Prado de Negreiros Nogueira Maduro; **Supervision-** Isolda Prado de Negreiros Nogueira Maduro, Sandro Adriano de Souza Lima Junior, Clara Valentina Noli

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Ethical Approval

This study was approved by the Research Ethics Committee of the tertiary care hospital, Fundação Hospital Adriano Jorge (FHAJ), under number 2.475.214.

Informed Consent

It was applicable.

Funding

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Data Sharing Statement

All referenced sources are accessible through the respective journals or public repositories.

Conflict of Interest

The authors declare no conflict of interest.

Similarity Check

It was applied by Ithenticate[@].

Application of Artificial Intelligence (AI)

Not applicable.

Peer Review Process

It was performed.

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